0251211: Building Capacity to Manage Watershed Impacts on the Belize Barrier Reef

Final Report

August 30th 2013

Maximiliano Caal
Project Manager
maximilianocaal@gmail.com | Mahogany Street, Punta Gorda Town, Toledo, Belize, C.A.

Devina Bol
Co-Project Manager
devinab05@gmail.com | Kiskadee Street, Punta Gorda Town, Toledo, Belize, C.A.

Golden Stream Watershed
Toledo District, Belize, Central America

Conservation Leadership Programme

Project Information

CLP Project ID:	0251211
Project Title:	Building Capacity to Manage Watershed Impacts on the Belize Barrier Reef
Host Country:	Belize
Site Location:	Golden Stream Watershed, Golden Stream
Field Dates:	Sampling: June 18th, 19th, 21st, 27th, 28th & 29th 2011, July 8th, 9th, 10th, 13th 2011, August 5th, 6th, 7th 2011 I August 29th & 30th 2011, September 1st, 3rd, 4th, 2011 I October 27th, 28th, 29th, 30th, 31st 2011, November 2nd & 3rd 2011 I December 27th, 28th & 29th 2011 I February 24th, 25th, 26th 2012 I April 23rd, 24th, 25th, 26th, 27th, 28th 2012. Sorting: July 6th, 7th, 15th, 16th, 17th, 18th, 19th 2011 I ID: January 30th, 31st 2012 I February 13th, 14th, 15th, 16th, 17th 2012 I March 26th, 27th, 28th, 29th, 30th 2012 I April 16th – 30th 2012 I June 18th – 30th 2012
Organisations:	Ya'axché Conservation Trust
Project Aim:	To build the capacity of para-biologists and students to undertake geographical and freshwater assessment whilst addressing data gaps about hydrology, land-use and the robustness of tropical freshwater bio-indicators to assess land-based run-off to the BBRS-WHS.
Authors:	Maximiliano Caal Devina Bol
Date of Report:	August 30th 2014

Table of Contents

List of acronyms

BBRS-WHS	Belize Barrier Reef – World Heritage System
CLP	Conservation Leadership Programme
DEM	Digital Elevation Model
GIS	Geographic Information System
GSW	Golden Stream Watershed
GPS	Global Positioning System
MMMC	Maya Mountain Marine Corridor
UK	United Kingdom
Ya'axché	Ya'axché Conservation Trust

Acknowledgements

This project was funded by Conservation Leadership Program (CLP). We are thankful to Robyn Dalzen, Stuart Patterson, Mike Kiragu, Julie Lewis and Christina Umrich at CLP for their support at various stages of the project.

We are indebted to Rachael Carrie, who has persistently provided guidance, technical and financial support to the project. We are also thankful to Nicola Jenner at FFI and Ken Kapinski at the University of Belize – Punta Gorda for their support.

We show our sincere gratitude to Ya'axche Conservation Trust for its technical, financial, and logistical support for the implementation of the project. Specifically, we thank Ivanny Oliva – for oversight of funds, Lisel Alamilla – for guidance, Lee Mcloughlin – for facilitating schedules to meet our fieldwork and Marchilio Ack – for providing transportation for project team. We indebted to Jaume Ruscalleda for his assistance in GIS work during imagery analysis.

We are thankful for the dedication the team members have shown during the implementation of the project. Last but not least, we thank the Fisheries Department of Belize for the support they provided.

Section 1:

Summary

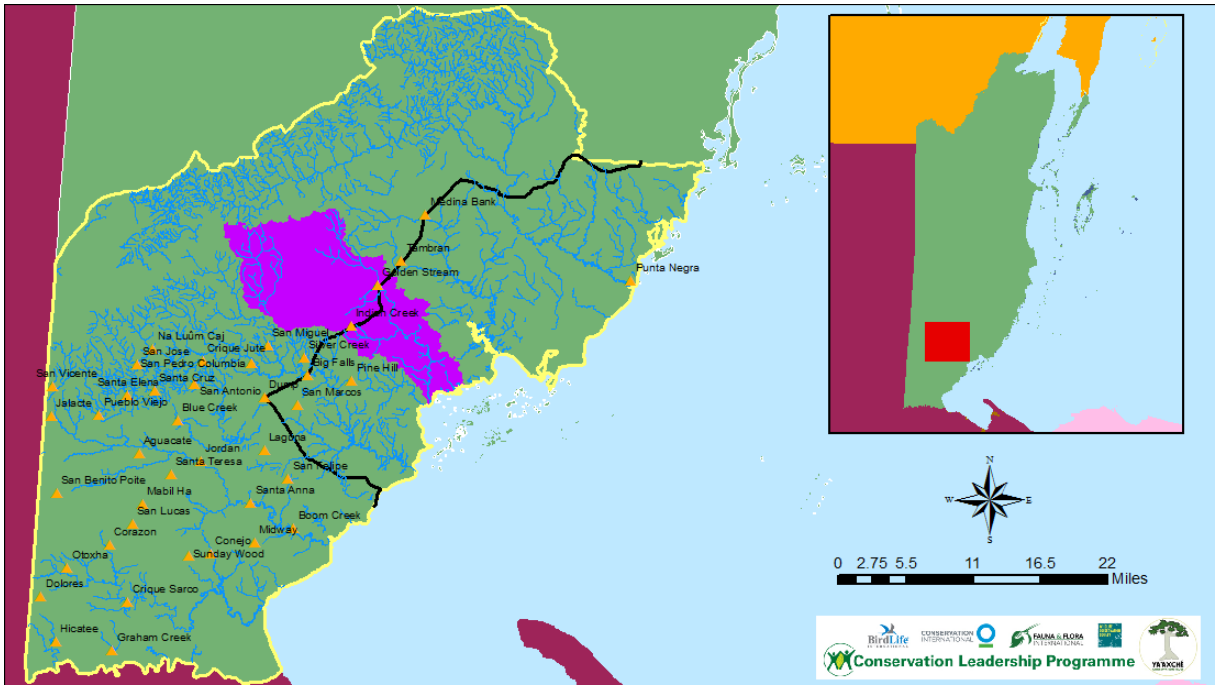
We aimed at analysing seasonal variation in some biotic metrics that are increasingly used to assess neotropical streams. By undertaking field work to achieve these aims our project's over-arching goal was to develop the capacity of future conservation leaders to monitor and assess watershed impacts.

Three of our five sites selected were forested in the upstream catchment and one site located downstream of a milpa farm with 80% of its drainage area deforested. The highest scores for sites were recorded in April at the end of the dry season. This indicates that families considered indicative of good stream condition increased after the rain stopped. The site located below a citrus plantation showed higher temperature and lower dissolved oxygen levels.

Team members because efficient in field work: team members are able to collect GPS points and navigate, collect macro-invertebrate samples, proficient in sorting and identifying macro-invertebrates that lead to the description of a new species, river substrate mapping. At least two persons are able to design posters with confidence and using ArcMap and Remote Sensing software for mapping.

Three rangers have led a rapid ecological expedition to a remote location of a strictly protected area without the supervision of an expert. The project has changed the mentality of rigorous field work to an enjoyable and rewarding activity, young conservation leaders unfolding.

Introduction



Map 1. The Golden Stream Watershed empties into the Belize Barrier Reef System, Toledo District, Belize.

This project is focussed on building certain aspects of capacity for monitoring and managing rivers. Additionally scientific data will be collected and will feed into a wider study which aims to develop river bio-assessment tools appropriate for use in Belize.

Land-based run-off is ranked second in its potential impact to the Belize Barrier Reef System- World Heritage Site (BBRS-WHS). Biotic metrics are used to measure land-based impacts on general stream health. Information about how biotic metric scores vary with season is not known in Belize.

Freshwater systems connect the terrestrial and marine environments and can provide an indication of ecosystem health. Land use has been linked to water quality by numerous studies that have concluded that decreases in forested land results in diminished river habitat quality and biota. River biota, particularly macro-invertebrates, is commonly used in the temperate world to assess riverine condition. This method is less widely practiced in the tropics for a number of reasons, including limited information about the macro-invertebrates present in rivers and the ways in which their populations fluctuate temporally and spatially.

It is a well-established fact that many insect species have life cycles that are seasonal, and that this results in fluctuations in the numbers of certain groups of macro-invertebrates occurring in samples taken at different times of the year. The use of macro-invertebrate bio-assessment tools in the temperate world is based on this knowledge of their seasonal variation. Seasonal variation has not been well researched in the tropics. The research with the macro-invertebrates will look at changes in the macro-invertebrate community every two months, to see if and how they vary in

composition throughout the year. It will also look at the influence of season on macro-invertebrate metrics that are commonly used, to describe river condition. A research is also being done in the area that is looking at how well commonly used metrics perform in rivers in the Maya Mountain Marine Corridor (MMMC).

The GIS work will contribute some explanatory variables such as percentage drainage catchment forested and drainage catchment area which, along with physicochemical information (e.g. discharge, nutrients etc), can be used with biological data to explore seasonal changes. These variables can help to explain what is happening in the river, the relationship between macro-invertebrate populations and land-use over time and over space may have statistically significant relationship among them.

Information from this project is of great importance to Ya'axché that do not have access because of data gaps. For a developing country where resources are not being managed sustainably, developing the capacities of young conservationist in the arena is of high value. It is important for the team to learn such valuable technique in watershed assessment. Managing watersheds and rivers provides a mechanism to reduce impact to the reef

Ya'axché along with communities of Indian Creek and Golden Stream are the key partners. Ya'axché will provide technical and financial assistance to this project while communities provide valuable information about land-use classification.

Project Members

Maximiliano Caal is a student at the University of Belize – Punta Gorda Branch who is pursuing an associate degree in Natural Resources Management. Max is an indigenous Q'eqchi Maya who speaks Q'eqchi fluently. Max has been practicing GIS work from since 2011 and has been involved in conservation from since 2009. Max is currently employed at Ya'axché Conservation Trust as Program Support Officer. His experience in GIS has been important in further developing concepts in remote sensing. Max oversaw the implementation of the project, reporting, providing support in field work unrelated to GIS, collecting GPS points and analysis of satellite imagery.

Devina Bol, a recent associate graduate from the University of Belize – Punta Gorda Branch from the Natural Resources Management Program, shared project management with Max. Devina is an aquatic ecologist who has trained with Rachael Carrie, a PhD student at the Lancaster University in the UK. Devina brought valuable theoretical experience of conserving and identifying key species to the project. Through volunteer work, she gained practical experience of watershed science, particularly macro-invertebrate monitoring. Devina undertook and co-ordinated freshwater sampling at selected sites within the Golden Stream Watershed. She also undertook data analysis and reporting.

Anignacio Makin is an experienced ranger who is currently working with Ya'axché to protect approximately 115,000 acres of protected areas. Anignacio was born in the Golden Stream watershed and has only a primary school level education but has an excellent local knowledge of his environment and of the streams and rivers – a great guide. Anignacio is a motivated para-biologist who is excellent at collecting, sorting, identifying macro-invertebrate samples. He has experience in chemical monitoring of the rivers at Ya'axché and along PhD student Rachael Carrie. Makin is a great leader and organiser in field work activities: conducted the substrate mapping, collected macro-invertebrate samples, sorted and identified most of the macro-invertebrates.

Octavio Cal is also an experienced ranger working for Ya'axché and was born in the Golden Stream watershed like Anignacio. Octavio has only a primary education level of education but grasps what he is taught very quickly. Octavio has experience in sampling rivers in Toledo for macro-invertebrates, river flow and chemistry and is also trained and took part in the Belize national assessment of the endangered Hikatee turtle. He is familiar with the project area and knows a lot about river ecology. Octavio also conducted substrate mapping, collected macro-invertebrate samples.

Abelino Zuniga is an experienced ranger in enforcing law in two protected areas that Ya'axché manage. Abelino has only completed primary level education but his knowledge of forest and river ecology is amazing. He has conducted freshwater assessment with PhD students Rachael Carrie as well. He is great at measuring river flow which was important for the project. Abelino left Ya'axché almost at the end of our project.

Pastor Ayala recently joined Ya'axché and shortly after joined our CLP team. Pastor has had little conservation background before joining Ya'axché. Pastor who has only a primary school level education has picked up the freshwater methodologies so quickly making him a great addition to the team. Pastor is a very studious ranger and is usually found reading books. He quickly picked up the roles of measure river flow and was instrumental in designing posters.

Section 2:

Aim and Objectives

We aim to analyse seasonal variation in some biotic metrics that are increasingly used to assess neotropical streams. By undertaking field work to achieve these aims our project's over-arching goal was to develop the capacity of future conservation leaders to monitor and assess watershed impacts.

The project had four main objectives:

Objective 1: Delineated the drainage area and characteristics of the Golden Stream Watershed (GSW)
The drainage area and characteristics of the Golden Stream Watershed data were available as a dataset (shapefile) to ArcMap. There wasn't any need to generate such datasets. The datasets (catchments, watershed, digital elevation models, direction flow grids, etc) were gathered from experts.

Objective 2: Quantify land-use characteristics within the Golden Stream watershed

Objective 3: Identify seasonal trends in biological indicator communities sampled from reference and impacted areas in the Golden Stream watershed

Objective 4: Develop the capacity of future conservation leaders to manage watershed impacts to the BBRS-WHS

Methodology

Dataset of the Golden Stream Watershed with its catchments had already been done. 30M resolution Digital Elevation Models (DEMs), the Golden Stream Watershed and its catchments were made available to us via Belize GIS & Remote Sensing Group on Facebook. There was no need to develop flow direction grid to determine watershed boundaries, drainage point and identify rivers and streams in the GSW because these data were available to us.

SPOT images have been provided through a Planet Action project received by Ya'axché. Pre-processing was conducted for the SPOT images that included a significant part of the GSW (three images, corresponding to the years 1989, 1999 and 2010). The pre-processing included: radiometric rectification (form Digital Numbers to reflectance values), spatial sub-setting of the images to our area of interest, geometric rectification (using the BERDS Belize roads map 2010), co-registration (with an error of less than a pixel), and layer stacking. Training areas were digitized and its separability checked. Maximum likelihood supervised classification was the method to classify the image, and a majority analysis (3x3 Kernel size) was performed to its output. A validation using the Landsat from a previous classification and the training areas were used to perform the validation of these classifications. All of the processes here mentioned were performed using ENVI 4.7. Almost two weeks was spent collecting GPS points for areas

that were of interest (eg. Forested, deforested, milpa, etc) which are called training areas. The training areas were used in the supervised classifications. The results were converted to shapefiles to enable potential stressor and natural environmental variables to be quantified for each bio-assessment location.

The classification only had 3 catergories cleared, forested and agriculture/milpa. The classification was overlaid by the catchments of the GSW and cut. The cut classification was then calculated for the entire drainage area, the total area cleared, forested and agriculture/milpa within each catchment.

We selected 6 sites prior to field work however because of heavy rains only five sites were suitable to assessment. The five sites then were assessed every two months. During each assessment at each site at least three samples or sets of data were collected. A rope was tied from one bank to the next, and flow was recorded almost every 5cm using a flow meter. At each site each type of substrate was mapped and macro-invertebrate samples collected at each substrate type mapped. Macro-invertebrate samples were preserved using ethanol and transported with care to prevent damaging macro-invertebrates. Nitrates, Phosphates, and Ammonia (all three used with reagents) and turbidity were measured using a Colorimeter. Temperature, pH, conductivity, dissolve oxygen were measure using a PCs Testr. Each test was done at least three times. Samples were preserved, processed in full and identified to family level. The data were recorded in an excel spread sheet for simple analysis to feed in the multivariate analysis software.

EPT family richness was calculated at each site for each sampling visit and the BMWP-CR score and the associated ASPT score. The component families of these scores are considered either sensitive or tolerant to organic pollution, but the scores are commonly used to assess general stream condition. We also looked at variation in physicochemical data and family level community composition using nMDS and PCA.

A local GIS professor provided short training sessions to team leader on data management on mapping software for 7 days. Ya'axché's GIS volunteer provided one-on-one training on GPS field data collection, GIS data analysis and remote sensing for 15 days. 3 freshwater monitoring workshops were held to cover all field and lab methods and was provided by a UK researcher conducting work in the area. A follow up workshop was held to further enhance taxonomy skill and using microscopic photography. A one day workshop was held to demonstrate Photoshop and Illustrator software in designing posters and a one-to-one training as a follow up training.

Outputs and Results

PhD Student, Rachael Carrie, has been doing her field work in Belize. She carried out a four-day training course at the beginning of the project on watershed field. The first day was a brief background on the importance of watershed field work and its conservation importance. The second day was assessing a riparian zone, measuring the width and flow of streams and mapping stream substrates where samples will be taken from. The third day involved best practices in collecting macro-invertebrate samples and preserving and testing streams for dissolved oxygen, pH, turbidity, conductivity, temperature, total dissolved solids, nitrates, ammonia and phosphate levels; all parameters important in watershed field work. All members of the team along with three villagers were able to do the above mentioned field work with minimal supervision.

Image 1. Devina at GS5 setting up small lab for testing chemical properties

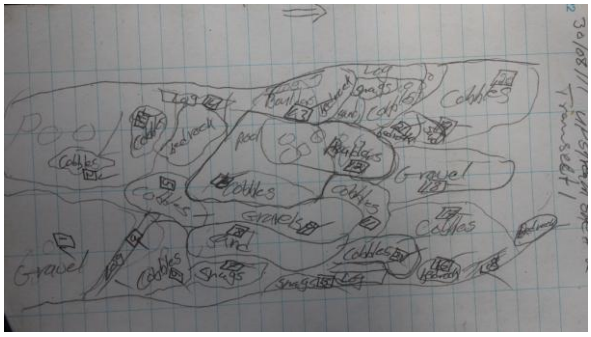


Image 2. River substrate mapping for GS5

Image 3. Anignacio collecting macro-inverts samples

Image 4. Octavio Cal & Anignacio Makin sorting macro-invert samples


Image 5. Devina Bol testing nitrate levels at site I **Image 6.**Octavio testing for Dissolve Oxygen

An Adobe Photoshop and Illustrator workshop was conducted to increase capacity in graphic design. The workshop was for two days for all members of the team and Ya'axché Education and Outreach Officer. The first day was a crash course on Adobe Photoshop CS3 and the second on Illustrator. At the end of the two day workshop each participant created a simple poster using techniques taught by a graphic designer. Max was able to create two professional posters using Adobe software.

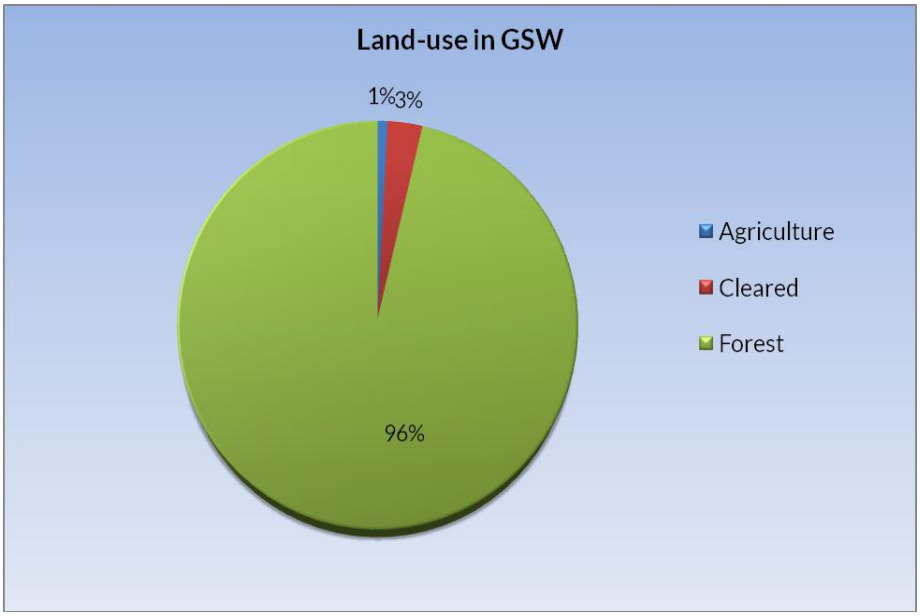

Image 7 & 8. Adobe Illustrator & Photoshop training for team members

Max had already some knowledge of mapping software and was mainly involved in GIS training along with Ya'axché GIS Officer. The GIS training involved a ten day period over the course of the project. Four days was dedicated to collecting GPS data of farms, citrus plantation, cleared areas, forested areas and community. These were important for GIS analysis because cleared areas or forested areas in remote location of GSW could be accounted for. Max along with GIS Officer were able to generate maps on land-use of the GSW and calculation of the different categories.

Since there were over seventy eight families to be identified, trainings was done at the ending of 2011. The trainings involved looking at small features that distinguished one macro-invertebrate family to another. Notes were developed to guide the process. At the end of the trainings Devina and Anignacio were able to identify sixty macro-invertebrate to family level.

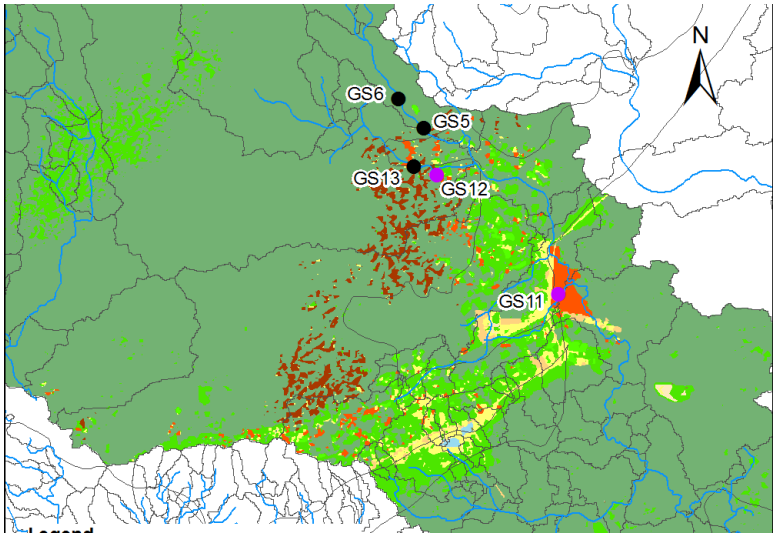

Image 9 & 10. Macro-invertebrate identification training by Rachael Carrie, PhD student

Since Devina and Max had some background in analysis, they were the only ones involved in multi-variate analysis. Rachael Carrie conducted two days on data analysis. Devina understood the process and was able to conduct analysis of data collected during the course of the project along with Rachael Carrie.



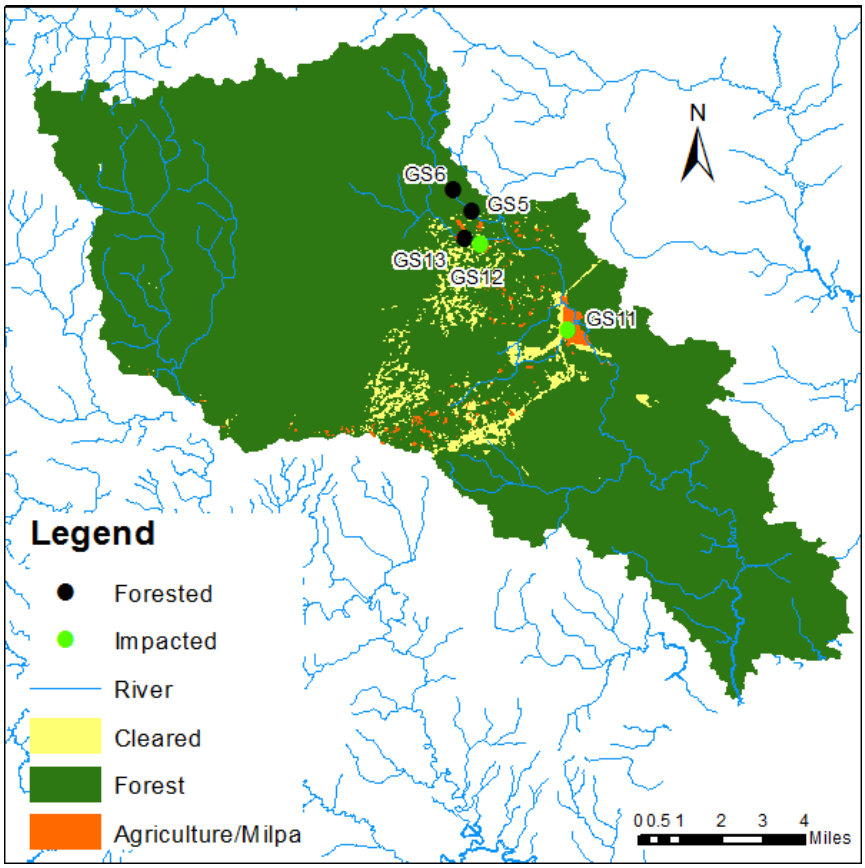
Garph 1. Landuse cover of the Golden Stream Watershed

The GSW has a drainage area of 86,750 acres. The GSW is still highly forested with only 3,470 acres being deforested.



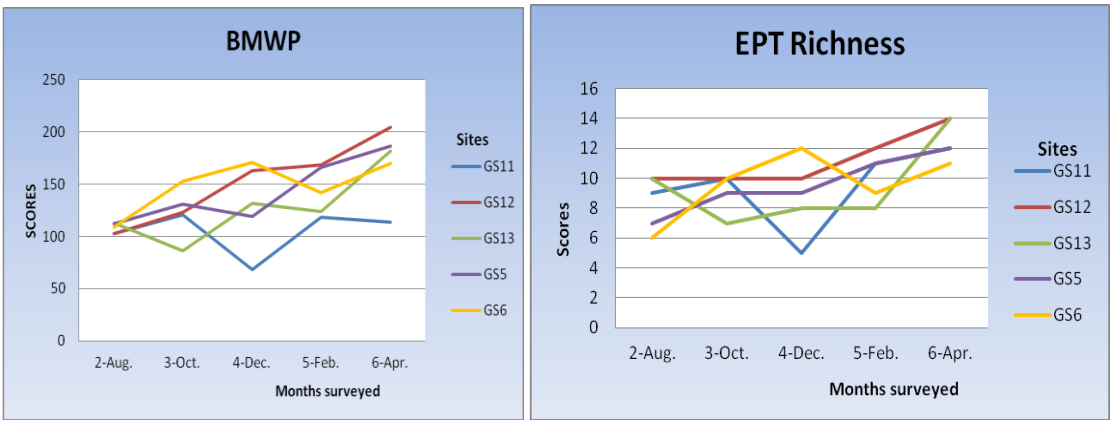
Map 2. Patches of dark & bright green shows forested areas within each catchment (gray boundaries)

GS5, 6 and 13 were forested in the upstream catchment. Site GS12 was also heavily forested in the upstream catchment but located downstream of a milpa farm. GS11 was located in a citrus farm and 80% of its drainage area was deforested.



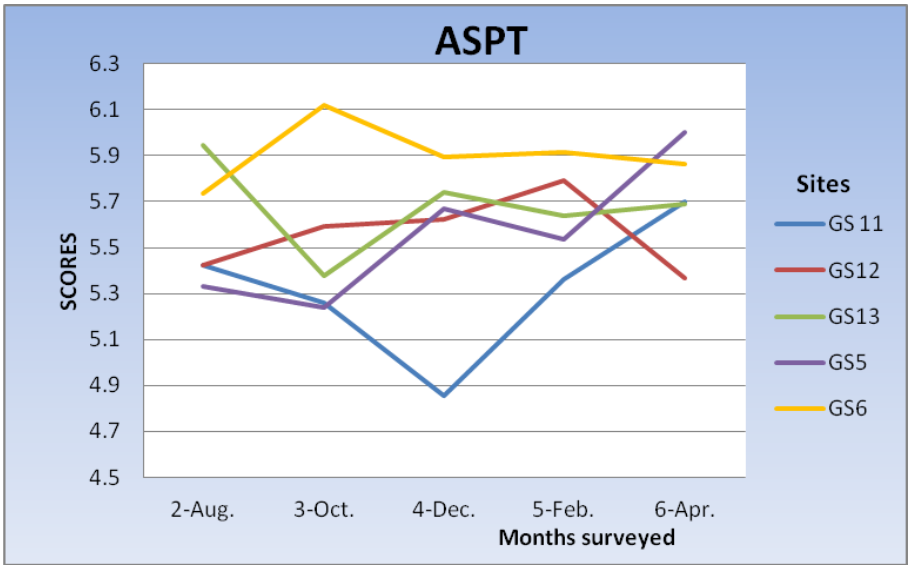
Map 3. Three significant landuse types within the Golden Stream Watershed

The land-use type cut for the GSW is available to the public. Map 3 shows the highly forested watershed.



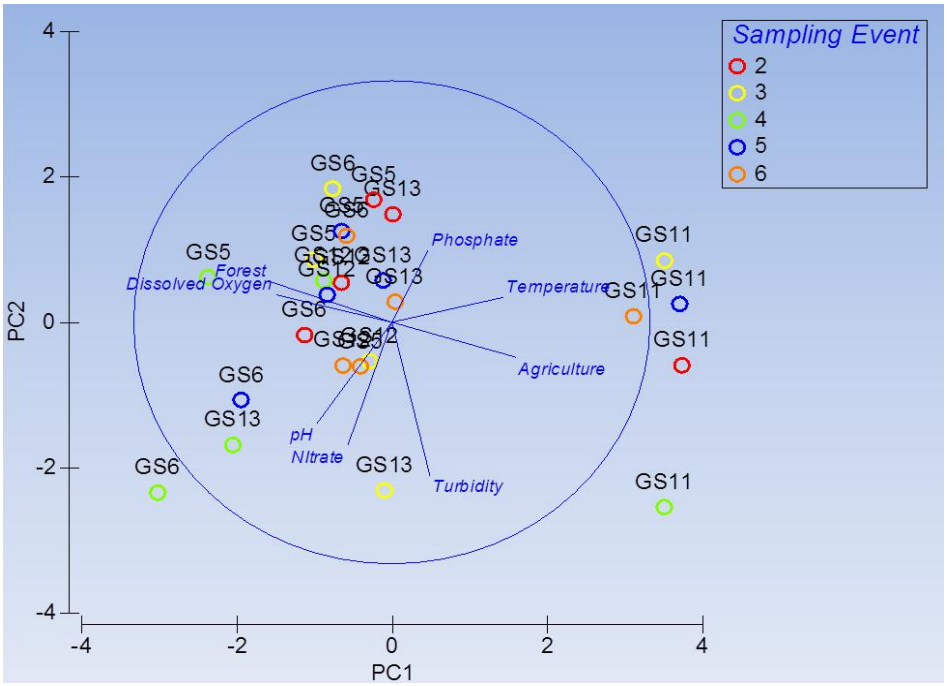
Graph 3 & 4. BMWP and EPT scores tend to increase as the dry season came.

BMWP and EPT scores tend to increase during the dry season. Highest scores were recorded in April: at the end of the dry season. This indicates that families considered indicative of good stream condition increased after the rain stopped.



Graph 5. The ASPT was more variable and lower at the end of the dry season at some sites.

GS11 tended to have the lowest BMWP and ASPT score throughout the year and there was a dip in all of the scores during December.



Graph 6. The multivariate analysis isolated GS11 which was more turbid and higher in temperature due to agriculture.

GS11 was environmental and ecologically distinct from the remaining sites mainly reflecting the proportion of agriculture and forest in the drainage catchments. Water temperature was higher at GS11 and dissolved oxygen lower than the other locations. There was some evidence of seasonality in nitrate, pH, and turbidity but patterns were not strong.

SITE_NO.	SITE_NAME	EASTING	NORTHING	No. of Samples
GS5	TRANSECT 1 D/S	304194	1813446	12
GS6	TRANSECT 1 U/S	303490	1814246	12
GS11	BELAM CREEK	307909	1808847	12
GS13	THERSEA MILPA CREEK U/S	303910	1812374	12
GS12	THERSEA MILPA CREEK D/S	304543	1812140	12
	TOTAL			60

Table 1. Locations of sites and number of samples collected.

60 surveys are completed throughout the project year. Macro-invertebrate taxa lists are available for five key sites. Appropriate metrics are calculated for each site and each sampling visit.


Image 12 &13. New team member Pastor Ayala fit in perfectly and he took responsibility seriously

Two posters were created by the team: a non-scientific poster by the rangers (CLP team members) and scientific poster by Max and Devina. Twenty five of each posters were printed and were given out to Ya'axché to give to six schools in communities that Ya'axché works with and twenty were given out to attendants of the Earth Day and fifteen at Natural Resources Management Symposium (mentioned below).


Image 14 & 15. One non-scientific poster in the making by rangers.

The team engaged in the University of Belize – Punta Gorda Branch yearly Earth Day. Over 300 students and teachers attended the event. The CLP booth captured the most attention. Devina Bol with her expertise in identifying macro-invertebrates challenged the intrigued students. We gave a brief presentation at the beginning of the event. The teachers were amazed of accomplishments and knowledge of watershed field of the young team. The head of the Natural Resources Department asked the team to present for an Environmental Impact Assessment course at the University of Belize. We stressed on the importance of macro-invertebrates as they are very sensitive creatures.

Image 16. Sharing knowledge to primary school students on Earth Day 2011

In 2013, we presented our findings to the science community at the University of Belize – Belmopan Campus attended by 250 students, 3 media houses, 25 professors, and 60 distinguished natural resources managers/environmental science managers. We received good feedback from the audience and were amazed at the knowledge of such a young team. Our abstract and poster submitted was accepted.

Image 17. Findings was presented to the science community in Belmopan

Achievements and Impacts

The GSW is still heavily forested and this is due to protected areas covering more than 80% of the area. The BMWP and EPT scores tended to increase during the dry season. The highest scores were recorded in April: at the end of the dry season. This indicates that families considered indicative of good stream condition increased after the rain stopped. This suggests that looking for indicators of general stream health would need to be done during the dry season. This is an important achievement. However, more research needs to be done on this to strengthen the point. It is likely that life-cycle or strong currents washing away macro-invertebrates may have an effect on results.

One site was located in a citrus plantation: this site with little forest cover in the catchment proved an increase in water temperature and lower in dissolved oxygen than other sites. This site also found species that are generally found in slow moving water. It is no mystery that deforestation have a major impact on streams and its ecology. It stresses the point that riparian zones need to be protected. This has already been acted up, it was placed in the goals of Ya'axché as they work closely with communities. It is understood that communities and population expand and the need for additional resources is in higher demand but priority needs to be given to riparian zones.

The underlining output from this project is building the capacity of young conservation leaders. Rangers are able to conduct river assessment: macro-invertebrate collection sorting, storage and identification, substrate mapping, chemical assessment, and physicochemical assessments. Anignacio now provides training to Natural Resources students from the University of Belize. From since 2012 Anignacio has provided training to 30 students. Devina has increased her knowledge on freshwater ecology, and data analysis, which enabled her to provide trainings to University of Belize research branch. Max has increased his knowledge in freshwater ecology, mapping, analysis, remote sensing and designing posters. From since the project has ended Max has been making presentations at the University of Belize to Natural Resources students on the project and Conservation Leadership Program. Apart from the project activities, the team has increased knowledge on climate change, media and messaging, behaviours and attitudes, advocacy and project planning.

With 10 posters and identification key available to communities, they can better understand the ecology of their rivers and streams. They can deduce whether a stream is in good condition depending on the macro-invertebrates found there. Children in school have learned about the new world that they have rarely noticed - the macro-invertebrate world.

There is now a list of macro-invertebrates found in the Golden Stream Watershed and information on land-use characteristics is available to communities and Ya'axché. This is a step forward in addressing data gaps. Plans have already been drafted for Belize to assess streams but funding and methodologies are not yet developed. Although we cannot conclude the health of the Belize Barrier Reef System but methodologies of the project and findings can be replicated and be looked at in streams across Belize. Only then will we have sufficient data on stream empting into the Belize Barrier Reef – World Heritage Site.

Section 3:

Conclusion

The GSW is relative high in forest cover. Forest cover plays an important role in the ecology of rivers and streams. The fauna at our most disturbed site was dissimilar to that of the other sites. Differences are reflected from the land-use and its influence on stream condition. The taxa typically associated with slow flows were found only here. Furthermore, the temperature was higher and dissolved oxygen lower at the most disturbed site. In addition, the BMWP and EPT scores tended to increase during the dry season. The highest scores were recorded in April: at the end of the dry season. This indicates that families considered indicative of good stream condition increased after the rain stopped. Variation in biotic metric scores over the course of our study suggests that the timing of sampling should be an important consideration when undertaking freshwater bio-assessment.

Our team became proficient at watershed fieldwork and GIS analysis. The field skills learned enabled our team to collect baseline macro-invertebrate information from the Snake Creek which contributed to the description of a new species. One member is proficient in designing posters.

Problems Encountered and Lessons Learnt

We missed the end of the dry season which was in May, the month the project was supposed to start. However, we did not receive funding on time to start as planned. We started assessments in late June when the rain started pouring. The river was flooded, muddy, not sufficient field supplies were taken thus resulting in missing data, equipment gave trouble. We waited until the river went down to do assessments. We became efficient in completing sites, our logistics improved as we went along.

An equipment broke, therefore we needed a replacement. The replacement was financed between Ya'axché and CLP project. This equipment was the PCs Testr 35Multi-parameter that measured conductivity, TDS, Salinity, PH.

We had conflicts with community members of using trails. They demanded that we open new trails that didn't go through community lands. This was not feasible as it would take more time to reach to sites. A meeting was held with village leader to discuss issue and was resolved.

Time was limited for all project members as they had other commitments beside the CLP project. We worked extra hours to complete tasks. The GIS training provided by Ya'axché's GIS volunteer went smoothly. Resources (GPS, transportation) were available. Ya'axché is a great organization that provided much dedicated support to the project.

The methodologies used for the project was well thought out. Freshwater monitoring aspects made sure there was little error in data collection for analysis. The GIS analysis gave the best results. The trainings provided were useful and assisted greatly in implementing the project.

For the project management part, it needed a lot more dedication and commitment. Although time was limited, every effort should have been made to communicating with funder and team members for an extension of the project.

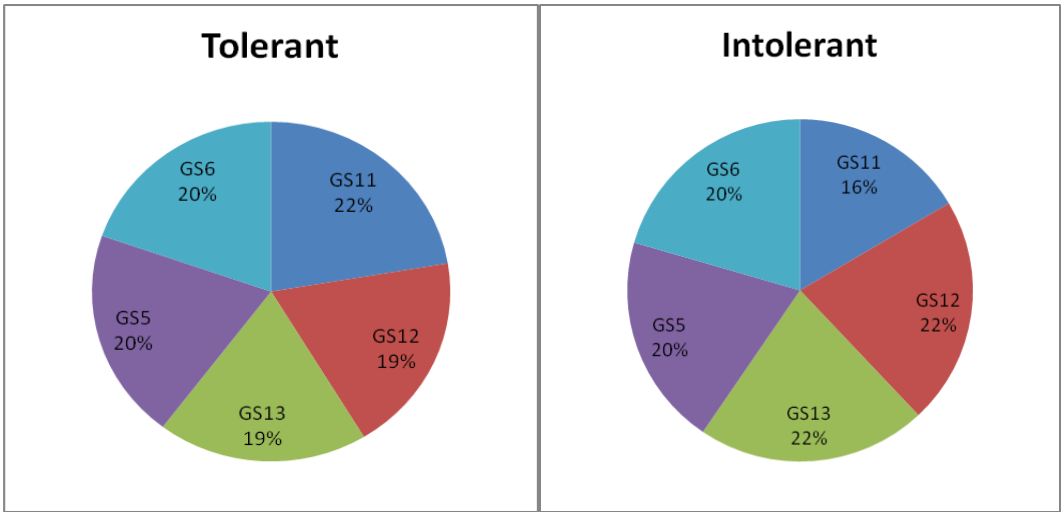
In The Future

Max is still undertaking GIS analysis and analysis of satellite images via remote sensing. The rangers are continuously assessing rivers to collect baseline data but not as frequently as when the CLP project was running but Ya'axché has realized its importance. We are seeking funding to continue our work in managing watershed. It is a long way to managing our resources sustainably. We have received the general idea that during dry season there is a higher score for sites. However, one year is a small period for making conclusion that developed tools elsewhere is replicable in Belize. A three year monitoring project in assessing whether biotic metrics developed can be used to determine general stream condition would provide more concreted evidence. This then could be the basis of a long term baseline data collection. The Maya Land Rights has granted some villages to have all powers over their land with little knowledge on community planning or land-use planning may have dire negative impacts on stream which would affect the Belize Barrier Reef – World Heritage System. Education on macro-invertebrates would be another step as communities living near rivers emptying into the Belize Barrier Reef impact the World Heritage System.

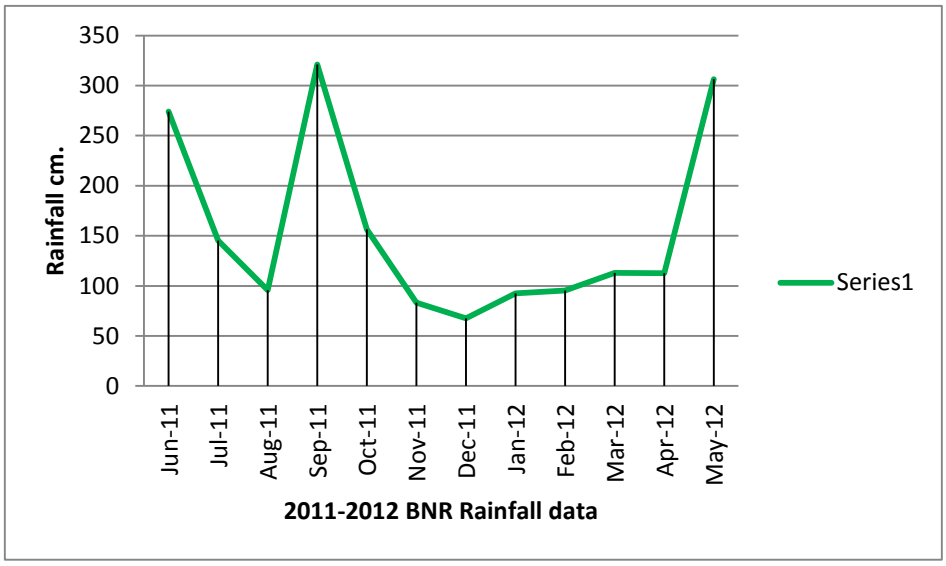
Section 4:

Appendices

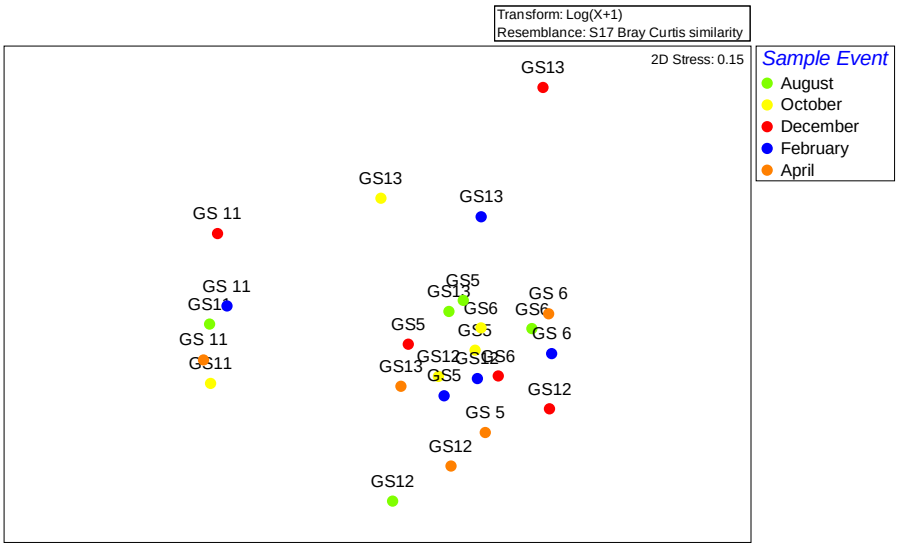
Itemized expenses	CLP Funds (USD)
PHASE I - PROJECT PREPARATION	
Administration	
Communications (telephone/internet/postage)	
Books and printing journal articles/materials	
Insurance (Accidental insurance for team members)	131.15
Visas and permits (Fisheries Department research permit)	100.88
Team training (Please detail: GIS and freshwater monitoring workshops)	2,000.00
Reconnaissance	
Medical supplies/first aid	
Equipment	
Scientific/field equipment and supplies (Please detail: Monitoring equipment, microscope & lab)	1,915.80
Photographic equipment (Please detail: Camera for microscope)	830.19
Camping equipment (Please detail main items:)	
Field guides	
Maps	
Boat/engine/truck (fuel for vehicle transport to sites for monitoring)	0.00
Fuel	
Other (Please detail: Fuel for generator for lights)	415.56
PHASE II - IMPLEMENTATION EXPENSES	
Administration	
Insurance	
Transportation	
Fuel	
Trip to Brasília to present Protectec Area proposal for government authorities	
Field vehicle maintenance	
Accommodation for team members and local guides	748.64
(Please detail: During transportation ($50 per day for 4 people * 8 days in the cities) 400.00	1,107.19
In the field ($210 per week for 6 people * 12 weeks) 2520.0)	
Food for team members and local guides (Please detail: Food in field ($210 per week for 6 people * 12 weeks) 2520.00)	3,936.09
Transportation	
Customs and port duties	
Workshops	
Outreach/education activities and materials (brochures, posters, video, t-shirts, etc.) (Please detail: 50 posters: 25 nonscientific & 25 scientific)	810.59
posters (150 items) 150	
t-shirts (50 items) 100)	
Other (Please detail: Intermediate Taxonomy, CS5 and data analysis workshops)	503.91
PHASE III - POST-PROJECT EXPENSES	
Administration	
Report production and results dissemination	
Other (Please detail:)	
Total	**12,500.00**



Graph 7 & 8. Sites and their tolerance/intolerance to organic pollution



Graph 9. Rainfall from June 2011 – May 2012



Graph 10.GS11 being the site in the citrus plantation is isolated from the clusters

Bibliography

AQEM CONSORTIUM (2002). Manual for the application of the AQEM system. A comprehensive method to assess European streams using benthic macroinvertebrates, developed for the purpose of the Water Framework Directive. Version 1.0, February 2002.

Esselman, Peter C. & Buck, David G (2007). Hydrological Assessment of Monkey River Watershed, Belize. Phase 1: Human Impact Mapping Along the Monkey and its Main Tributaries. April, 2007.

COMPACT (2007). Updated site strategy of The Belize Barrier Reef Reserve – World Heritage Site (BBRRS-WHS). November, 2007.

Ya'axché Conservation Trust (2009). A Freshwater Monitoring for the Maya Mountain Marine Corrodor. Toledo Institute for Development and the Environment. 2009.

Ya'axché Conservation Trust (2009). The Maya Mountain Marine Corridor Human Impact Mapping, Golden Stream and Deep River. 2009.

BUILDING CAPACITY TO MONITOR WATER QUALITY & LANDUSE IN SOUTHERN BELIZE

Maximiliano Caal [1,2], Devina Bol [1,2], Anignacio Makin [2], Octavio Cal [2], Pastor Ayala [2]
[1] University of Belize - PG Campus, [2] Ya'axché Conservation Trust

Conservation Leadership Programme

1. Rationale

Biotic metrics are used to measure land-based impacts on general stream health. Information about how biotic metric scores vary with season is not known in Belize.

2. Aim

We aim to analyse seasonal variation in some biotic metrics that are increasingly used to assess neotropical streams. By undertaking field work to achieve these aims our project's over-arching goal was to develop the capacity of future conservation leaders to monitor and assess watershed impacts.

4. Approach

We analysed SPOT5 satellite images using supervised classification to identify land-use types. We collected macro-invertebrates and physicochemical using standard methods[1].

We calculated EPT family richness at each site for each sampling visit and the BMWP-CR score and the asociated ASPT score. The component families of these scores are considered either sensitive or tolerant to organic pollution, but the scores are commonly used to assess general stream condition. We also looked at variation in physicochemical data and family level community composition using nMDS and PCA.

3. Study Area

We sampled 5* stream sites: 3 forested and 2 impacted in the Golden Stream Watershed (GSW) every 2 months between August 2011 and April 2012.

Site GS6 - has forests in its catchment, a forested site

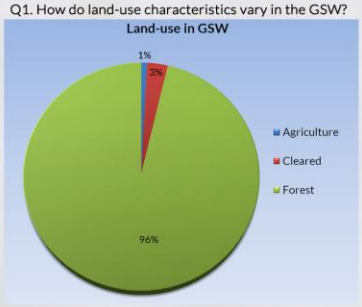
Site GS11 - is located in citrus plantation

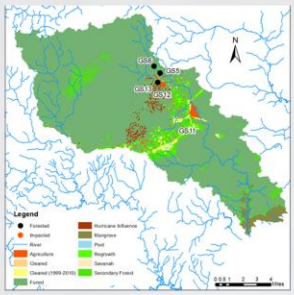
Site GS12 - is located near a corn plantation

* We were unable to sample the originally chosen 6 sites because of high flows.

5. Key Findings

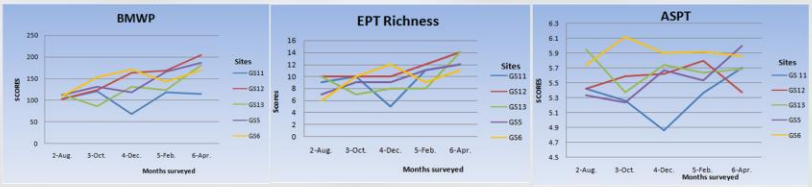
Q1. How do land-use characteristics vary in the GSW?





The GSW has a drainage area of 86,750 acres. GS5, 6 and 13 were forested in the upstream catchment. Site GS12 was also heavily forested in the upstream catchment but located downstream of a milpa farm. GS11 was located in a citrus farm and 80% of its drainage area was deforested.

Q2. Do biotic metrics vary seasonally?



BMWP and EPT scores tended to increase during the dry season. Highest scores were recorded in April: at the end of the dry season. This indicates that families considered indicative of good stream condition increased after the rains stopped.

ASPT was more variable and lower at the end of the dry at some sites. GS11 tended to have the lowest BMWP and ASPT score throughout the year and there was a dip in all of the scores during December.

Biotic metric scores were generally high.

Q 3. How do biological and physicochemical characteristics vary at the studied sites?

The macro-invertebrate community at GS11 was dissimilar in composition to the other sites. However community composition did not vary consistently throughout the year.

GS11 was environmental and ecologically distinct from the remaining sites mainly reflecting the proportion of agriculture and forest in the drainage catchments. Water temperature was higher at GS11 and dissolved oxygen lower than the other locations. There was some evidence of seasonality in nitrate, pH, and turbidity but patterns were not strong.

6. Capacity Building

We became skilled at methods of GPS ground-truthing, GIS spatial analysis, macro-invertebrate sampling and identification to family level, physicochemical monitoring.

Ranger Anignacio Makin collect biological samples.

Identification of macro-invertebrate taxonomy to family level training

Maximiliano Caal conducting GPS ground-thruthing

Adobe CS3 Photoshop training for designing poster

Regular meeting to share knowledge among the team was crucial in the success of the project.

The field skills learned enabled our team members sample Snake Creek, a remote site in Belize.

Sorting required hours of looking through samples for macro-invertebrates.

Children from primary schools engaged in small games in identifying live macro-invertebrate based on images.

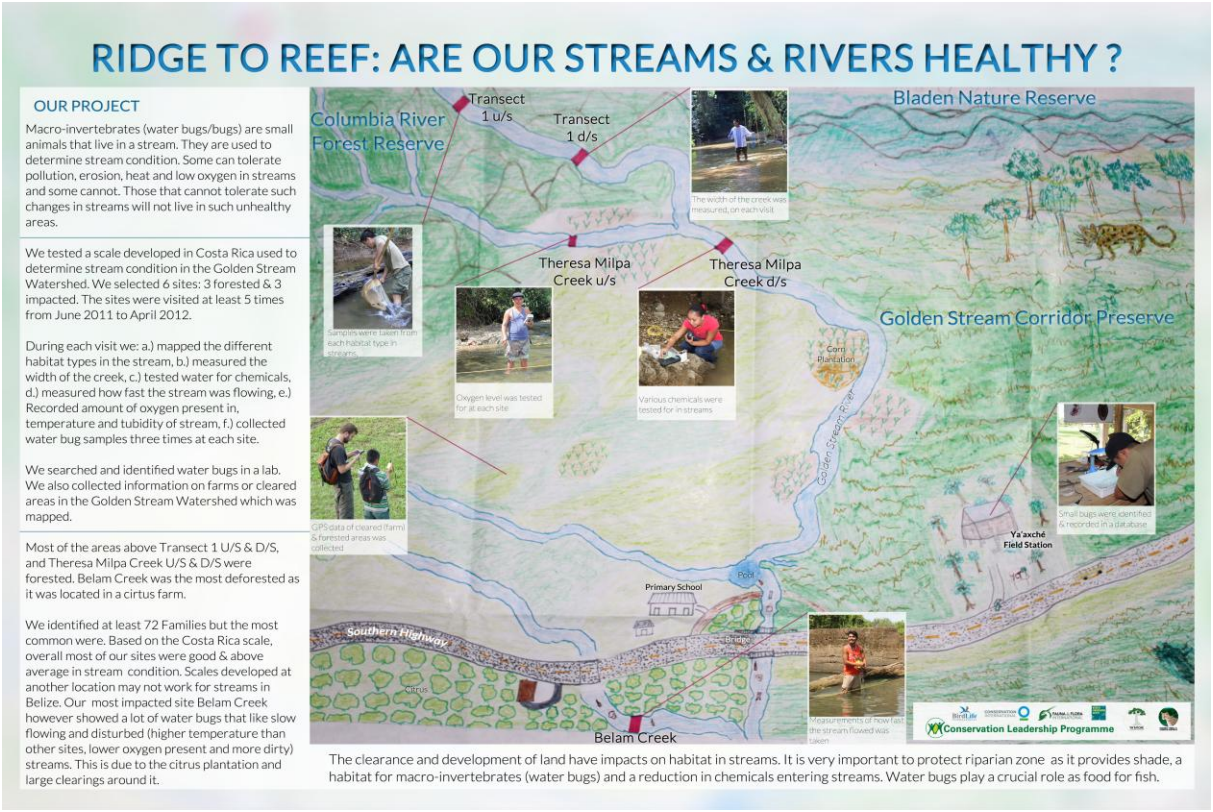
The team shared results at a science gathering to environmentalist and students from the University of Belize.

7. Conclusions and In The Future

Our team became proficient at watershed fieldwork and GIS analysis. The field skills learned enabled to collect baseline macro-invertebrate information from a remote site in Belize. Most sites were considered as good quality using Costa Rican criteria, but criteria cannot be translated to Belize without testing. The fauna at our most disturbed site was dissimilar to that of the other sites. Differences may reflect land-use and its influence on stream condition, and/or other physical difference at this site. Variation in biotic metric scores over the course of our study suggests the timing of sampling should be an important consideration when undertaking bio-assessment.

Acknowledgements: Lancaster Environment Center PhD student Rachael Carrie, Ya'axché Conservation Trust, University of Belize, The Government of Belize - Fisheries Department.

Graphic 1. Scientific poster displaying results of the project.

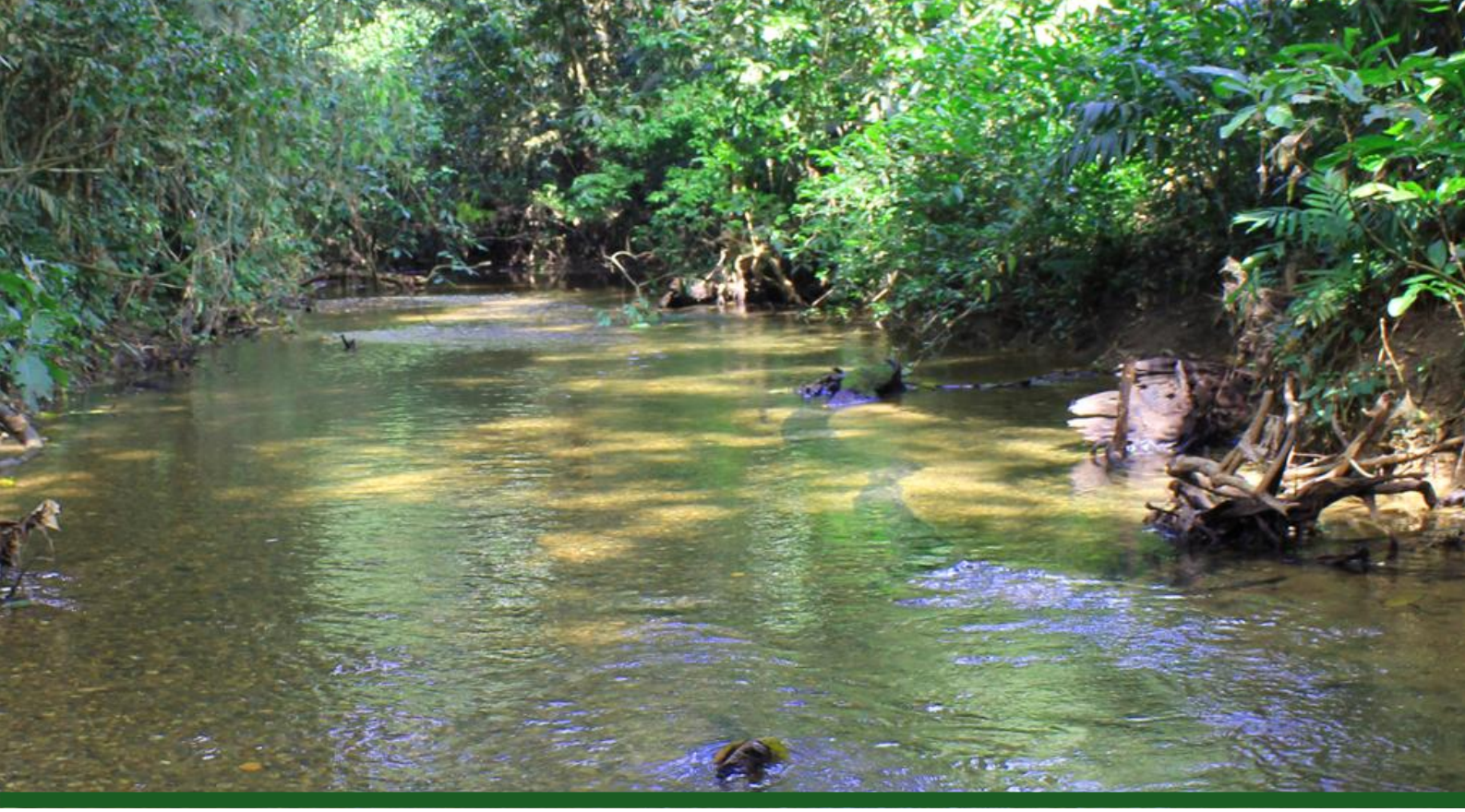


Graphic 2. Non-scientific poster for primary school children and communities

Image 18. Anignacio & Devina speaking logistics at GS13

Image 19. Anignacio mapping substrates at site GS6

Image 20. Maximiliano giving presentation to UB students about CLP program



Conservation Leadership Programme

0251211: Building Capacity to Manage Watershed Impacts on the Belize Barrier Reef

Final Report
August 30th 2013

Maximiliano Caal
Project Manager
maximilianocaal@gmail.com I Mahogany Street, Punta Gorda Town, Toledo, Belize, C.A.

Devina Bol
Co-Project Manager
devinab05@gmail.com I Kiskadee Street, Punta Gorda Town, Toledo, Belize, C.A.

Golden Stream Watershed
Toledo District, Belize, Central America

Contact
Maximiliano Caal
Mahogany Street, Punta Gorda, Toledo District
Belize

Phone: (+501) 632-7688
E-mail: maximilianocaal@gmail.com